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§36. Analysis for Plasma Wall Interactions in LHD and Characterizations of Co-deposited Carbon Film Using Material Probes

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Control of plasma-wall interactions in fusion devices is a key issue for the improvement of the plasma parameter toward to commercial fusion reactor so that the interactions in the present device must be investigated and improved. In addition, carbon deposition incorporating hydrogen isotope has been recognized as one of significant concerns in the point of view of safety and particle control in the fusion reactor. In the present study, plasma-wall interactions in the LHD were evaluated by means of material probe analysis. Namely, the distributions of impurity deposition and fuel gas retention during discharges were investigated. Also, the co-deposition of carbon and hydrogen in the LHD was also evaluated.

The material probes made of 316LSS with boron (B) or titanium (Ti) thin film for the evaluations of plasma-wall interactions were prepared by using a technique of electron beam evaporation and then exposed for the main discharges and/or the glow discharges near 8.5L and 10.5L ports in the 12th experimental campaign. The material probes for the evaluation of the co-deposited carbon film were also placed on the inner side wall in the vicinity of helical divertor of 6.5 sector. After the campaign, the probes was taken out and then analyzed. The impurity deposition and the amount of deposited carbon were evaluated by means of Auger electron spectroscopy and scanning electron microscope, and the gas retention was evaluated by means of thermal desorption spectroscopy.

Carbon deposition and iron deposition was observed for the probes after the exposure of the main discharge or the glow discharge. The iron deposition for the probe after the exposures of main discharges might be associated with the main discharge experiments with the movement of the striking point to the stainless steel wall near the divertor plate and also the iron deposition on the divertor plate. Fig. 1 shows the amount of retained hydrogen for material probes before/after the plasma exposures. While the hydrogen uptake by the main discharge were clearly observed for the probes both with B and Ti film, the amount of retained hydrogen for Ti probes after the exposure of glow discharges was similar to that before the exposure. These results indicate that little hydrogen retention and/or surface erosion occurred during the glow discharges. The amount of retained helium for B probe exposed to glow discharge was similar to that for the probe exposed to main discharge. The amount of retained helium for Ti probe exposed to the glow discharge was one order of magnitude smaller than that exposed to the main discharge. Thus, the deference among the probe materials for the retention of low energy fuel gas particles was clearly observed.

The hydrogen concentration in the films deposited near the local island divertor (LID) in 11th experimental campaign was estimated to be ~0.5 in the atomic ratio of H/C in our previous study[1]. Figure 2 shows hydrogen concentration and film thickness in the carbon films deposited on the probes installed in the vicinity of helical divertor for the 12th campaign[2]. Hydrogen concentration of the carbon film deposited in the vicinity of the helical divertor was a little smaller than that of the film deposited near the LID head in 11th experimental campaign. For the helical divertor configuration, it might be difficult for the hydrocarbon to arrive to the probes by the ionization in close plasma and the subsequent trapping by the magnetic field. In addition, the temperature of the probe in the vicinity of the helical divertor during the discharge might become high, compared with that of the probes near the LID head. The differences in the deposited particle and the temperature during the discharge might be responsible for the difference structure of the deposited film, which was strongly connected with the hydrogen concentration. For the probe relatively far from the helical divertor, D2 shown in fig.2, the thickness of the deposited film was very small (~5 nm), so that it was difficult to evaluate the hydrogen concentration of the film.

The structures of the films deposited in the vicinity of the helical divertor or the LID head will be evaluated and then the difference in the deposition mechanism of co-deposited carbon film would be clarified. In addition, the deposition mechanism of the carbon film at the shadow region in the vicinity of the helical divertor will be also investigated in the future study.

1) Hama, R. et al: To be appeared in J. Nucl. Mater. (2010).
2) Hama, R: The master's thesis, Hokkaido University (2010).

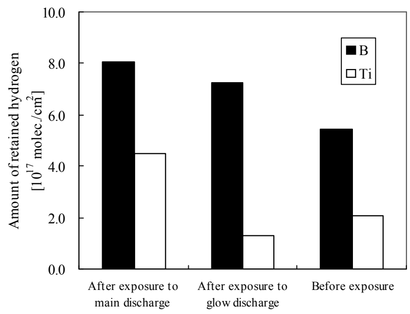

Fig.1. Hydrogen retention of material probes before and after plasma exposure.

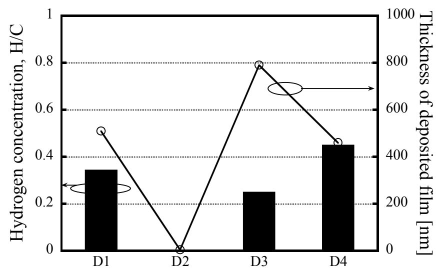

Fig.2. Hydrogen concentration and film thickness of co-deposited films on probes in a vicinity of helical divertor.